Chapter 5
Technological Utilization in Africa: How Do Institutions Matter?

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5.1 Introduction

In recent times, there is an increased research effort and conclusion on the role of technology, especially Information and Communication Technology (ICT), on economic growth across countries. However, little empirical work has focused on how the level of institutional development in a particular country (institutional quality) and the level of economic development in countries can improve or impair the level of ICT utilisation. This is even more disturbing for African countries that have experienced low ICT utilisation in the phase of institutional 'palavers'. Needless to say that the nature and extent of institutional quality and level of economic development can influence the rate of diffusion and utilisation of a given form of technology given that institutional quality creates a platform for improved economic interactions that protect economic agents from potential losses. Consequently, the expected outcome from such a system is improved trust for the particular technology, which will result to better ICT diffusion. This is the main argument that informed this study with the main objective to empirically explore the nexus between institutions, economic development and ICT utilisation in Africa.

The growth of ICT utilisation can be seen from the improved use of ICT infrastructures such as electronic payments in the financial sector, the operations of the government and administrative procedures, in education, improved business activities and transportation, among others (Mukoyama 2003; Osabuohien and Efobi 2012). Despite this upsurge of ICT utilisation across the world, in many

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African countries, the level of ICT utilisation is low. This is evidenced by the value of some indicators of ICT utilisation, with African region scoring lower than those of other regions of the world. For example, the average Internet usage per 100 persons in Sub-Saharan Africa (SSA) was 3.97 between 2005 and 2008 compared to other developing regions like Latin America and the Caribbean (LAC) and the global average that had the values of 16.37 and 20.58, respectively (World Bank 2011).

Following the low level of ICT utilisation in Africa, some studies have traced this performance to a number of factors. They include low level of educational attainment/low literacy rate, low per capita income, poor infrastructural development, outbreak of diseases, weak institutional quality, among others (Dimitrios and Ourania 2003; Musa et al. 2005; Osabuohien and Efobi 2012). Despite the appreciable effort of these studies, the interconnectedness between institutional quality and human development in informing ICT utilisation has inadvertently been avoided. The interconnectedness between these variables and its effect on ICT utilisation in Africa requires attention due to the fact that African countries are beginning to echo on developmental policies that encourages human development (United Nations Economic Commission for Africa-UNECA, 2010). Likewise, the role of institutional development has been emphasised and it is accountable for the reason why the region lags behind in many respect. The implication of these on ICT utilisation is not clear. This in itself presents a worrisome situation because institutions are supposed to govern human behaviour and enhance the attainment of human development for economic outcomes including ICT utilisation (North 1994; Williamson 2000; Rodrik 2008; Acemoglu 2010; Osabuohien and Efobi 2011, 2013); therefore, neglecting this nexus accentuates a lopsided discussion on the factors that enhance ICT utilisation in Africa.

In a view to empirically situate the focus of this study, an econometric model was formulated and analysed using a panel data for 45 African countries across the five subregions (Central, East, North, Southern and West Africa) for the period 1995-2010. The main variables of interest include institutional quality and human development and ICT utilisation. The Generalised Method of Moments (GMM) technique was employed in estimating the model in order to handle the issue of endogeneity and to handle the possibility of spurious regressions. The chapter is structured into six sections. The second section presents some stylised facts on the indicators of ICT utilisation, which is followed by the literature review in the third section. Methods of analysis comprising of empirical model and estimation technique were discussed in the fourth section. The fifth section presents and discusses the results, while the last section concludes with some policy recommendations.

5.2 Some Stylised Facts

In general terms, ICT utilisation connotes the ability of ICT to have a broad influence in a country as it relates to ICT usage by economic actor such as households, firms and the government. This has been noted to be one of the distinguishing factors between economies (Mukoyama 2003; Osabuohien and Efobi 2012). This section appraises the level of ICT utilisation in Africa in comparison to other regions of the world. The comparison also cuts across the five subregions in Africa.

Table 5.1 presents the Internet users per 100 persons, fixed (wired) broadband subscriptions per 100 persons and active mobile broadband subscriptions per 100 persons, which are basic indicators of ICT utilisation (International Telecommunication Union 2010; World Bank 2011). As can be seen in Table 2.1, the number of Internet users per 100 persons was lowest in Africa compared to the other regions of the world, all through the period 2006–2010. Similar trend was observed using another indicator of ICT utilisation, namely, the fixed (wired) broadband subscriptions per 100 persons where the value for Africa ranged between 0.1 and 0.2 from 2006 to 2010. This was also lower than other regions. For instance, in 2010, the average values for Asia and the Pacific and Commonwealth of Independent States (CIS) were 5.5 and 8.3, respectively. These were more than 27 and 41 times greater than that of Africa's value of 0.2 within the same period.

Another indicator reported in Table 5.1 is the active mobile broadband subscription per 100 persons, which measures the extent of usage of mobile Internet facility. The values from the table reveal that Africa performed lower than other regions except for CIS in 2008. In 2010, the value for Africa was not only the lowest but many times lower than other regions. In effect, it was about three times lower than those of Asia and Pacific; four times lower than those of Arab States; more than

Table 5.1 Indicator of ICT utilisation (Internet) across regions of the world

			Internet users per 100 persons		Fixed (wired) broadband subscriptions per 100 persons		Active mobile broadband subscriptions per 100 persons		
Region	2006	2008	2010	2006	2008	2010	2006	2008	2010
Africa	3.3	6.3	10.8	0.1	0.1	0.2	Na	1.0	2.5
Arab States	10.9	17.3	24.1	0.5	1.3	1.9	Na	2.4	10.2
Asia and Pacific	10.6	16.5	22.5	2.8	4.0	5.5	Na	4.3	7.5
Commonwealth of Independent States (CIS)	12.6	19.5	34.0	1.3	4.5	8.3	Na	0.8	11.2
Europe	49.8	60.3	67.0	14.8	20.7	23.8	Na	24.2	41.3
The Americas	38.8	44.2	50.7	9.1	12.4	14.1	Na	10.3	24.1

Source: Authors' compilation from International Telecommunication Union (2010)

Table 5.2 Indicator of ICT utilisation (telephony) across regions of the world

	Fixed telephone lines per 100 persons			Mobile cellular subscriptions per 100 persons		
Regions	2006	2008	2010	2006	2008	2010
Africa	1.5	1.5	1.5	17.9	32.4	45.2
Arab States	9.6	10.3	9.8	39.3	63.4	87.9
Asia and Pacific	15.5	14.9	13.6	28.8	46.6	69.2
Commonwealth of Independent States	24.7	26.1	26.2	81.8	112.5	134.8
Europe	45.3	42.9	40.7	101.2	117.7	117.7
The Americas	31.9	31.5	29.5	62.0	81.5	94.5

Source: Same as in Table 5.1

Table 5.3 Indicators of ICT utilisation across the subregions in Africa

Indicators	Africa	Central	East	North	Southern	West
Internet users per 100 persons	2.42	1.64	3.11	5.25	2.36	1.44
Telephone (Mobile + Fixed) users per 100 persons	12.96	6.11	14.29	28.87	14.54	9.04

Source: Authors' computation using data from World Bank (2011)
Note: The values are presented using the averages for the period 1995–2008. All African countries were used in the computation except Liberia and Somalia due to data availability

nine times lower than Americas; and more than 16 times lower than those of Europe. Likewise, fixed telephone lines per 100 persons and mobile cellular subscriptions per 100 persons are reported in Table 5.2 and the extent of ICT utilisation using these indicators was also lowest in Africa compared to other regions of the world. The average number of fixed telephone lines per 100 persons in Africa in 2010 is about seven times lower than the Arab States, nine times lower than Asia and pacific region, 17 times lower than CIS, 20 times lower than the Americas and 27 times lower than Europe. A similar pattern can be underscored using mobile cellular subscriptions per 100 persons, where the values for Africa was many times lower than other regions as well.

Some of the indicators of ICT utilisation are presented in Table 5.3 across the five subregions in Africa, namely, Central, East, North, Southern and West Africa. From the table, the average value of Internet users and telephone (mobile + fixed) users per 100 persons was 2.42 and 12.96, respectively. However, across the subregions, a disparity was observed. For instance, Internet users per 100 persons in Central and West Africa are as low as 1.64 and 1.44, respectively. The highest value (5.25) was observed for North Africa, which is more than three times above the value of Central and West Africa.

Similarly, the value of telephone users per 100 persons is also lowest in Central Africa (6.11), followed by West Africa with a value of 9.04. The highest telephone usage is in North Africa with a value of 28.87, which is distantly followed by Southern Africa (14.54) and East Africa (14.29). In fact, the values for Central and West Africa are 4.73 and 3.19 times lower than that of North Africa, while those of

East and Southern Africa are about 100 % lower than North Africa. The basic observation from the above discuss is that the Central and West Africa had the lowest extent of ICT utilisation, while the highest was in North Africa.

The main issue to be summed in this section is that Africa has witnessed low level of ICT utilisation compared to other regions. Thus, investigating on the factors that can matter for the improvement of this trend will be worthwhile.

5.3 Literature Review

The extent to which ICT utilisation occur in a country has received empirical attention. This has resulted into the development of some models that explains the factors that enhance this process. They include the innovation-diffusion model, economic constraints model, adoption perception model, the epidemic model, the rank-order model and the stock model. Among these models, the innovation diffusion model stands out, especially when considering the ICT utilisation framework of African countries.

The innovation diffusion model is premixed on the position of Rogers (1995) that the extent of technology utilisation is based on the amount of information about the technology that are accessible per time to the potential adopters of the technology. Rogers proposes that the process of technology adoption follow a five-step process: knowledge about the technology, persuasion to use the technology, decision to adopt the technology, implementation (actual usage of the technology) and confirmation (assertion that the technology is worth using). This implies that technology utilisation is not an end in itself, but a systemic process, which is only feasible among members of a social system.

Any technology can be accepted in any system based on the systemic framework and the information asymmetry within such system. As Mudzonga (2012) observed, technology is devoid of cultural meaning and the extent of its penetration is based on effective communication and persuasion. Similarly, Uaiene et al. (2009) observed that technology is culturally and technically appropriate, but the extent of information asymmetry can usurp its adoption process. Apart from the extent of information flow within the economic system, some other heterogeneous traits of members that constitute the economic system also affect the extent of technology utilisation.

Mudzonga (2012) classified members in the economic system as innovators, early adopters, early majority, late majority and laggards. The members adopt technology based on their innovative capacity. This heterogeneity among the members of the economic system will account for the s-shaped trend in technology diffusion process. Thus, the technology utilisation process follow a period of slow utilisation, then gradual increase in utilisation, after which a rapid utilisation will occur when the technology has been accepted by the members of the system, then a gradual decline begins to occur. The gradual decline is caused by introduction of new technologies in the economic system. This flow is illustrated in Fig. 5.1,

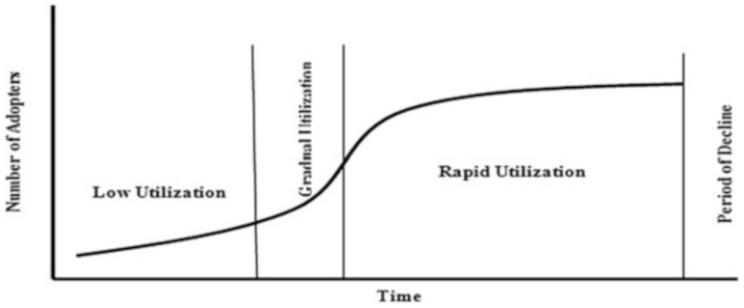

Fig. 5.1 S-curve illustrating technology utilisation process (Source: Adapted from Rogers (1995), Osabuohien and Efobi (2012))

From this model, the extent of education of members of the economic system matter in determining the extent of ICT utilisation. This can be observed from the fact that the heterogeneous diversities among the members of the economic system are based on their innovative capacities and without gainsay; the innovative capacity of individuals cannot be disassociated from their level of education (Mudzonga 2012). Furthermore, the reduction of information asymmetry within the economic system is directly linked to the strength of institutions, prevalent in the country. Developing economies have hitherto experienced poor institutional framework to facilitate information access. This was further confirmed in Columbus (2012) who ascertained that the common feature of developing countries is information poverty as a result of information inaccessibility, which can be enhanced by the development of institutions. Need to say, the decisions of economic agents are largely influenced by the available institutions. This is based on the fact that institutions shape the behaviour of economic agents and create incentive for economic relationships that reduces the risk of economic losses and moral hazard (North 1991; Williamson 2000; Greif 2006; Acemoglu and Robinson 2008). For agents to strive towards accepting a technology and ultimately utilising the technology, the institutional paradigm can go a long way to ensure the suitability of any technology inflow to the country. This relieves the agents of the pressure of finding out about the suitability of such technology and thus encouraging the utilisation process.

There are avenues through which technology can be introduced into an economic system. Some of these avenues include trade, such as import of technologies into a country. Some others include FDI flow such as technology transfers (e.g. Carr et al. 2001, Dirk 2006); however, this study is not concerned about the source of inflow but on eventual utilisation of the technology. Before the technology can be eventually utilised, some intermediaries that fashion the belief system of users are predominant. This includes the formal institutions in the form of government policies and regulations; the level of human development of the users such as their educational attainment and level of income; and the informal institutions.

The formal institutions matter in the technology utilisation process. As observed by North (1991) and Rodrik (2008), sound institutions protect economic agents (users) from possible moral hazards that can occur from economic relationships. An economic system with better institutions will act by defending the interest of economic agents and ensure that technology inflow does not have possible adverse effect on users. This may not be entirely ensured, since the ultimate decision to use a technology lies on the agent. However, the role of institution in protecting the rights of economic agents and ensuring a fair hearing in the case of moral hazard can build confidence in the users. This confidence will be translated to the trust that economic agents have for any technology that has been certified by the government, based on certain standards. This will further translate to the acceptance of the technology and then utilisation.

When institutions are weak, economic agents loose trust in technology inflow. This is based on the fact that they do not trust that the government certification of the technology is based on quality and reduction of moral hazard, but on rent seeking and private gains. Fosu and O'Connell (2006) and Fosu (2011) observed that this has remained the bane of African country as political elite make national policies for private gains instead of public interest. In this case, the economic agents become sceptical about adopting a technology and in cases where they have to adopt; they require extreme caution in making the decision to adopt.

In a similar fashion, the level of development of potential adopters, in the form of education, can explain the extent of ICT utilisation. Guerrieri et al. (2011) opine that high human capital development can expedite the rate of technology utilisation because potential adopters are able to understand and utilise the new technology. Kiiski and Pohjola (2002) also observe, from the study of mix samples that comprise of countries from both developing and the Organisation for Economic Co-operation and Development (OECD), that tertiary education had a positive significant influence on the utilisation of ICT. Some other studies note that the level of human capital does not have a significant impact on ICT utilisation. Baliamoune-Lutz (2003) using sample from 47 developing countries, points out that the level of education is not associated with the ICT utilisation. Similar observation has been made for industrialised countries (Kiiski and Pohjola 2002). Norris (2000) also underscores that human capital (education) does not have a significant influence on the extent of ICT utilisation from a sample of both developed and developing countries.

From the general standpoint, studies on the determinants of ICT utilisation are in twofold: micro- and macro-analyses. Studies focusing on the micro-analysis have ascertained that ICT utilisation is influenced by the human capital capacity, the income of the individual adopter, the nature of the new technology to be adopted, firms characteristics (such as the size of the firm, performance of the firm), among others (Jensen 1982; Chari and Hopenhayn 1991; Haller and Traistaru-Siedschlag 2007). Studies on the macro perspective have concentrated on the *digital divide* which is the divergence existing in the rate of technology utilisation between developed and developing countries (Guerrieri et al. 2011). The *digital divide* has been attributed to the difference in economic wealth of countries (Guerrieri

et al. 2011). Baliamoune-Lutz (2003) asserts that a country with higher income level will spend more on research and development, which will in turn boost ICT utilisation. Contrasting view has been observed, as some studies noted that the wealth of the countries may not be a significant factor for explaining the extent of ICT utilisation (Hargittai 1999; Beilock and Dimitrova 2003).

In the light of the earlier discussions, it is important to note that there has been an inadvertent exclusion of conclusions for the factors that inform ICT utilisation in African countries. This is particularly considering that the region is faced with poor human capital development as well as an increasing proportion of the world's poorest people, with low standard of living (Cohen 2002; Mills 2010; United Nations Economic Commission for Africa-UNECA 2010). In a similar fashion, African countries are characterised by poor institutional quality (Fosu 2011; Osabouhien and Efobi 2013, 2014). Therefore, applying the conclusions of other studies that have concentrated on ICT utilisation of other regions may not be sufficient for policy implications for African countries.

5.4 Methods of Analysis

The study engaged two main methods of analysis to achieve its objectives, which include descriptive and econometric analyses. The former involves the use of summary statistics on the indicators of ICT utilisation, human capital development and institutional quality. The second aspect of the analysis used the Generalised Method of Moments (GMM) econometric technique to capture the relationship between the indicators of ICT utilisation, economic performance and institutional quality.

5.4.1 Econometric Model

The extent of ICT utilisation has been measured in extant literature using different approaches such as Internet users per capita, mobile phone subscribers per capita (Baliamoune-Lutz 2003; Beilock and Dimitrova 2003), expenditure on information technology (Luciani and Padoan 2007), personal computer per capita (Haller and Traistaru-Siedschlag 2007), among others. Some others have used the extent of utilisation of ICT for economic activities like purchasing, email account per person, email users (Bayo-Moriones and Lera-Lopez 2007) and the price of ICT services (Kiiski and Pohjola 2002). Some of these measures are not accessible, for instance, reliable data for price of ICT services and expenditure on information technology are not available for African countries. Also, email account per person, utilisation of ICT for economic activities can be accessed for micro-studies but are not available for macro-studies such as this. Thus, similar measure of ICT utilisation used by Baliamoune-Lutz (2003) is most preferable for this study.

The econometric model formulated for this study gleans on Baliamoune-Lutz (2003) determinants of equilibrium level of ICT utilisation. The model examines the relationship between technology utilisation-*T*, income and a vector *Z*, which includes other variables like institutions, openness of the economy and level of education. This is expressed in Eq. (5.1) as:

$$\mathrm{Ln}T*_I = \beta_0 + \beta_1 \ln \mathrm{INCOME}_i + \lambda^i Zi \tag{5.1}$$

Equation (5.1) can be extended by considering the possibility of institutional quality influencing human capital and income level of a country (Fosu 2011). This is expressed in an interaction form that includes the multiplicative between institutional quality (*Instq*) and the economic performance variables (*human capital development-Hdev* and *income-Rpgdp*). These are denoted as *Instq*Hdev and Instq*Rpgdp*.

Therefore, the empirical model for the study is stated as:

$$\begin{aligned} ICTuti_{it} = \beta_0 + \ & \beta_1 Instq^n{}_{it} + \beta_2 Hdev_{it} + \beta_3 Rpgdp_{it} + \beta_4 Instq * Hdev_{it} \\ & + \beta_5 Instq * Rpgdp_{it} + U_{it} \end{aligned} \tag{5.2}$$

where:

ICTuti: Indicator of ICT utilisation measured as the simple average of three main indicators of ICT, namely, telephone and mobile phone utilisation (*Tel)*, Internet utilisation (*Itnet*) and personal computer usage (*Pcom*) per 100 persons.

Instq: Indicator of institutional quality derived from the simple average of rule of law (*Rl*) and regulatory quality (*Rq*). This approach has been used recently by Fosu (2011), who compared the terms of trade between Nigeria and Botswana by focusing on their institutional quality. The measures *Rl* and *Rq* are essential indicators of institutional quality because the rule of law *(Rl)* explains the extent by which economic agents have confidence in and abide by the rules in a country, thus translating to the protection of property rights. It includes the effectiveness of the judiciary system, the incidence of crime and the enforceability of contract. Likewise, the regulatory quality *(Rq)* measures the incidence of market friendly policies in the country. Thus, reflects the ability of the government to formulate and implement sound policy that will enhance the private sector development, thus translating to ICT utilisation. The values of *Rl* and *Rq* as computed by Kaufmann et al. (2009) range from −2.5 to +2.5; the higher, the stronger the institutional quality.

Hdev: Human capital development was measured using the Human Development Index (HDI). The HDI shows the extent of human capital in the country taking into consideration the health,

education and income status of the population in a given country. The index is ranged between 0 and 1, with the higher value signifying better human development. A country with HDI value above 0.80 is regarded as high; those between 0.50 and 0.80 are regarded as medium; while below 0.50 is regarded as low human developed country (UNDP 2010).

Rpgdp: Growth rate of the real per capita income of the country measures the growth rate of the real gross domestic products (GDP) at 1990 constant prices.

*Instq*Hdev*: The interaction between the institutional quality and the level of human development in the country.

*Instq*Rpgdp:* The interaction between the institutional quality and the growth rate of real per capita GDP.

U_{it}: The error term that captures other factors influencing ICT utilisation not included in the model. They are assumed to be identically and independently distributed (*iid*) with zero mean and constant variance.

it: Country's and time identifiers.

The *apriori* expectation is such that: $\beta_i(i = 1 - 3) > 0$. This implies that an improvement of institutional quality, human capital development and real per capita income growth rate will lead to better level of ICT utilisation. The signs of β_4 and β_5 can be negative or positive (−/+) depending on the nature of interactions between institutional quality and the indicators of economic performance. When the coefficient of *Instq*Hdev* is positive, it suggests that institutional quality enhances ICT utilisation in a country where human capital is developed. Thus, better institutional quality is complementing human capital development to improve ICT utilisation, vice versa. Similarly, when the coefficient of *Instq*Rpgdp* is positive, it implies that better institutional quality is congruent with per capita income growth to enhance ICT utilisation, the converse holds if the coefficient is negative.

5.4.2 Estimation Technique

The model formulated in Eq. (5.2) was estimated using econometric technique, using static and dynamic panel data estimators. The static panel analysis was done with Fixed Effects (FE) estimator. The choice of FE over the Random Effects (RE) was based on Hausman test. The dynamic panel data estimator was carried out using the Generalised Method of Moments (GMM). The GMM is similar to the Two Stage Least Squares (2SLS) for 'just identified' models. However, the GMM gives precise estimates with 'over-identified' models. The GMM estimation is considered appropriate for this study because it internally generates the instruments

used in the estimation process unlike the 2SLS method where the researcher has to look for valid external instrumental variables. In addition, innovations in current technology usage can affect future utilisation. This is represented in the model as lagged dependent variable [*ICTuti (-1)*]. This introduces the issue of autocorrelation and endogeneity in the model, which can be handled by the GMM estimator compared to the 2SLS (Arellano and Bond 1991; Grubler 1991; Jovanovic and Lach 1997).

In view of the above, Eq. (5.2) can be modified to include the lagged dependent variable and stating it in GMM model format as:

$$ICTuti_{it} = \beta_0 + \beta_1 \Delta ICTuti(-1) + \beta_2 \Delta Instq_{it}^{n} + {}_3\Delta Hdev_{it} + \beta_4 \Delta Rpgdp_{it} + \beta_5 \Delta Instq * Hdev_{it} + \beta_6 \Delta Instq * Rpgdp_{it} + \Delta\mu_{it} \quad (5.3)$$

The sign 'Δ' is the change coefficient that represents the dynamic mechanism in the model.

The data engaged were sourced from the World Development Indicators (WDI) of the World Bank (2011) and the Human Development Indicators (HDI) of the UNDP (2010) for the period 1995–2010. The analysis was carried out using STATA 11.1 software. Forty-five countries in Africa were selected based on data availability.[1] The sampled countries represent over 80 % of the countries in Africa covering the five subregions, namely, Central, East, North, Southern and West Africa.

5.5 Results and Discussions

The descriptive analysis of the variables, especially, the indicators of ICT utilisation and institutional quality was carried out using their respective indicators instead of the average with a view to observing their nature as reported in Table 5.4. From Table 5.4, the selected African countries had low values in the indicators of ICT utilisation with respect to Internet usage (*Itnet*) and personal computer usage (*Pcom*) per 100 persons. The average utilisation rate was 2.09 for personal computer usage per 100 persons and 2.40 Internet users per 100 persons. The telephone usage (*Tel*) had the mean value of 13.29 users per 100 persons, which equally appeared low. Using the minimum and maximum values, it could be inferred that the difference between the country with the ICT utilisation rate and that of the least

[1] The countries include: Algeria, Angola, Benin, Botswana, Burkina Faso, Cameroon, Cape Verde, Central Africa Republic, Chad, Comoros, Congo Republic, Cote d'Ivoire, Democratic Republic of Congo, Djibouti, Egypt, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea Bissau, Guinea, and Kenya. Others are: Libya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria, Senegal, South Africa, Sudan, Swaziland, Tanzania, Togo, Tunisia, Uganda, Zambia, and Zimbabwe.

Table 5.4 Descriptive statistics of variables

Variable	Mean	Std. deviation	Minimum	Maximum	Observations
Rpgdp	2.74	7.14	−29.63	65.77	626
Hdev	0.51	0.13	0.27	0.85	542
Rl	−0.62	0.63	−1.88	1.00	449
Rq	−0.49	0.71	−2.37	1.75	448
Pcom	2.09	3.73	0.02	24.04	471
Tel	13.29	21.73	0.07	125.72	601
Itnet	2.40	4.77	0	38.98	601

Source: Authors' computation

was as much as 24, 39 and 125 for personal computer, Internet and telephone usage per 100 persons. This implies the existence of disparity in ICT utilisation in Africa.

Indicators of institutional quality as reported in Table 5.4 had the mean values of −0.63 and −0.49 for regulatory quality (*Rq*) and rule of law (*Rl*) for the sampled countries. The minimum value for the selected countries was as low as −1.88 for rule of law and even lower for regulatory quality with the value of −2.37. The implication of the above is that, on the average, the strength of institutional quality of the sampled countries is relatively weak. This observation is similar to the submission of Sanjeev and Ourvashi (2006) who noted that the strength of African institutions may be one of the reasons for the low growth in investment as investors (inclusive of ICT devices) can be encouraged to invest in countries with reliable institutional quality.

The indicators of human capital development *(Hdev)* and the growth rate of the real per capita GDP *(Rpgdg)* show that the sampled African countries have mean value of 0.51 and 2.74 % for *Hdev* and *Rpgdg*. The range between the country with the highest GDP per capita growth rate and that of the lowest is as much as 95.40 %. Similarly, the country with highest value in *Hdev* and the lowest was as much 0.58. This reflects the huge difference among African countries with regard to the indicators of economic performance.

The study observes from the descriptive analysis that in the selected African countries there is a prevalence of low value indicators of ICT utilisation, economic performance and institutional quality. Thus, the level of impact of economic performance and institutional quality on ICT utilisation is reported in the next subsection using econometric technique.

The results from the econometric analysis using Fixed Effects (FE) and Generalised Method of Moments (GMM) are reported in Table 5.5. The choice of FE over Random Effect (RE) was based on the Hausman test as the estimates from the FE was observed to be more efficient that RE. However, only the results of FE are reported in columns 1–3 in Table 5.5 for sake of brevity. As noted in the preceding subsection, there was huge difference in the range of values of the respective variables, which suggest the existence of country fixed effect, thus making a case

Table 5.5 Econometric results using FE and GMM (1995-2010)

	Dependent variable: ICT utilisation (ICTuti)					
	FE			GMM		
Variables	(1)	(2)	(3)	(4)	(5)	(6)
Cons	−41.4716[a]	−40.3222[a]	−42.1045[a]	−0.2977[a]	−0.2428[a]	−0.2821[a]
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0002)	(0.0001)
Hdev	90.9007[a]	89.6643[a]	91.9470[a]	1.2181[a]	1.0729[a]	1.2013[a]
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0001)
Rpgdp	0.0217	0.0273		0.0023[a]	0.0014[a]	0.0199 [a]
	(0.6468)	(0.5604)		(0.0000)	(0.0076)	(0.0000)
Instq	2.3558[c]		2.6324[b]	0.2750[a]		
	(0.0821)		(0.0410)	(0.0000)		
Instq*Hdev		3.0337			0.6918[a]	
		(0.3416)			(0.0000)	
Instq*Rpgdp			0.0712			0.0243[a]
			(0.1530)			(0.0030)
ICTuti (-1)				1.1726[a]	1.1741[a]	1.1727a
				(0.0000)	(0.0000)	(0.0000)
R-squared	0.8234	0.8219	0.8240			
F-Stat.	20.3321	20.1320	20.4149			
	(0.0000)	(0.0000)	(0.0000)			
Breuch Pagan	53.1592	44.4885	52.2964			
	(0.0000)	(0.0000)	(0.0000)			
Hausman test	12.5963	13.5694	13.1559			
	(0.0056)	(0.0036)	(0.0000)			
AR (1)				−1.2833	−1.2885	−1.2832
				(0.1994)	(0.1976)	(0.1994)
AR (2)				−0.1422	−0.1658	−0.1418
				(0.8869)	(0.8683)	(0.8872)
Sargan test				42.3883	42.4138	42.5136
				(0.9786)	(0.9784)	(0.9778)
Number of countries	45	45	45	45	45	45

Source: Authors' computation
Note: Values in bracket are the probability values. Superscripts [a], [b] and [c] represent significant at 1, 5 and 10 %, respectively

for the use of FE.[2] From the table, the coefficients of institutional quality and human capital development significantly influenced ICT utilisation. However, there may be the issue of endogeneity using FE. Thus, the GMM results, which help to resolve the issue of endogeneity, are reported in columns 4–6 of Table 5.5. Based on the above, the study focuses discussion on the estimates from GMM technique.

[2] The respective country fixed effect was not reported as it was not the main focus of the study and for sake of brevity.

To evaluate whether the problem of endogeneity was handled as well as test the validity of the instruments, the Sargan/Hansen[3] test for over-identifying restrictions and the second-order serial correlation test *AR (2)* test were carried out. From Table 5.5, it can be observed that the instruments were valid given the fact that the probability values for the Sagan/Hansen test and the *AR(2)* test were not significant at 5 %. There was no first-order serial correlation-*AR(1)* from the results; however, *AR(2)* and the validity from the Sargan/Hansen test shows that the instruments were not over-identified.

An examination of the coefficients of the explanatory variables in columns 4, 5 and 6 of Table 5.2 shows that the significant level of institutional quality changed from 10 % and 5 % to 1 %, which is an indicator of improvement of the results using the GMM estimator. The result helps to establish the fact that a unit improvement in the quality of institutional quality in Africa will help to boost the rate of ICT utilisation by 0.28 units. The implication of the above is that for African countries to advance in ICT utilisation, there is a need to improve the quality of their institutional quality especially adherence to rule of law and improvement of regulatory quality. This submission is crucial given the fact that most of the 'stimulants' of ICT utilisation such as property rights and innovations are to be protected by law in order to give the needed incentive for idea generation that are imperative for ICT utilisation.

The results in Table 5.5 indicate that human capital development has positive impact on ICT utilisation, which is statistically significant at 1 %. The coefficient denotes that a unit increase in the rate of human capital development will result in about 1.22 units of improvement in ICT utilisation. The main implication of this finding is that there is need to enhance the quality of human capital in Africa with a view to improving the level of ICT utilisation. This can be driven by improvement in functional educational system, continuous relevant on-the-job training, which will help boost innovation and technical know-how. This is because technical skills are essential for enhancing ICT utilisation.

The growth rate of real per capita income (*Rpgdp*) was found to significantly exert positive influence on ICT utilisation. This tends to support the fact that the income level in the country can affect the rate of ICT utilisation. The above observation is in line with the rank order model of ICT utilisation, where wealth of the individuals in a country can influence the rate of ICT usage (Caselli and Coleman 2001). Another observation from columns 4, 5 and 6 is that the previous level of ICT utilisation can influence its current value. This implies that ICT utilisation is time dependent. Thus, current level of ICT utilisation can be used to predict its future level. The connotation of this is that immediate efforts geared

[3] The Sargan/Hansen test is asymptotically distributed as a chi-square with degree of freedom equal to the number of instruments less the number of parameters. For the model to be correctly specified, the variables in the instrument set should be uncorrelated with the idiosyncratic component of the error term.

towards improving ICT utilisation will have long-run effect on the level of ICT utilisation in Africa; *the earlier the better*.

Other findings that can be made from the study are based on the two interacting variables presented in columns 5 and 6 of Table 5.2. The result from Column 5 reveals that the coefficient of the interaction between institutional quality and human capital development had significant and positive influence on ICT utilisation. The implication of this finding is that institutional quality will enhance ICT utilisation in a country given the *complementarity* of human capital development. Thus, in Africa, improving institutional quality in the light of developing human capital is essential for ICT utilisation. This may be interpreted based on the relevance of human capital development process such as education and health built on strong institutional quality for improving ICT utilisation, which cannot be overemphasised.

Similar result was observed for the interaction between ICT utilisation and the growth rate of real per capita income, which came out with a positive sign and significant at 10 %. The result reveals that institutional quality can complement real growth of per capita income in enhancing ICT utilisation in the selected African countries. Thus, the growth rate of per capita income in a country has important influence on ICT utilisation especially where the institutional quality is relatively strong.

Conclusion

Information and Communication Technology (ICT) utilisation, like most other forms of technology, can be influenced by the institutional quality as well as level of economic performance in country, which this study set out to examine. This is with the main objective of investigating the extent to which institutional quality and economic performance exert impact on ICT utilisation in Africa. The study used descriptive and econometric analyses to achieve its objective. Some of the major findings of the study are summarised here.

Based on some indicators of ICT utilisation, the study found that the level of ICT utilisation in Africa was far lower than other regions of the world. This is similar to the findings that the strength of institutional quality of the sampled African countries was rather weak. This study found that institutional quality positively and significantly influences the level of ICT utilisation in Africa. This implies that for African countries to advance technologically with respect to ICT utilisation, as often aspired, there is the need to frantically strengthen the level of institutional quality especially the rule of law and regulatory quality. This is essential as the adherence to the tenets of the rule of law and enhancement in quality of regulation can affect some of the key issues of ICT utilisation such as protection of property rights, innovations and creativity.

(continued)

The study also established that human capital development, one of the indicators of economic performance, exhibit positive and significant influence on the level of ICT utilisation. The implication of this finding is the need to urgently improve the quality of human capital in Africa, which will significantly improve the level of ICT utilisation. One of the ways this can be achieved is through improvement of the educational system, which will help to drive the essential technical know-how as well reduction of information asymmetry as knowledge will be better transmitted when there is functional knowledge system in a society. An improvement in the level of economic performance in a country will significantly lead to the enhancement in the level of ICT utilisation. This suggests that one of the ways to improve the level of ICT utilisation in Africa is to enhance the growth of the economies. This is not far-fetched as a high performing economy will have the wherewithal to innovate, diffuse as well as utilise the required form of technology including ICT.

In précis, institutional quality matters a great deal in explaining the rate of ICT utilisation in Africa just as the indicators of economic performance: growth rate of per capita income and human capital development are also essential. Thus, strengthening the institutional quality, harnessing human capital and increase in per capita income will help in the quest of African countries to improve their level of ICT utilisation. Thus, this concludes that efforts that will strengthen institutional quality, on one hand, improve level of human capital development and the growth rate of real per capita income, on the other, will play important role in enhancing the level of ICT utilisation in Africa. In this perspective, regulatory bodies charged with responsibility of formulation of technical innovations through broad-based consultation is also recommended. This is built on the understanding that institutional quality will enhance ICT utilisation in a country, when it is complimented with human capital development. In other words, the relevance of human capital development process such as education and health as well as growth rate of per capita income built on strong institutional quality for improving ICT utilisation are fundamental.

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